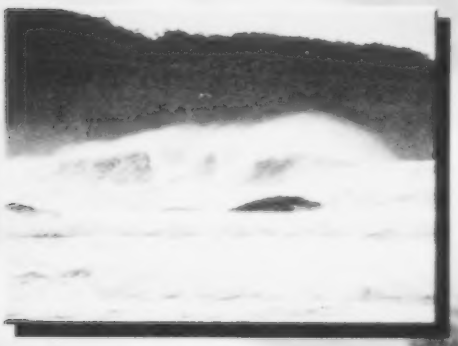
Environment Canada Environnement Canada

The Meteorological Service of Canada

Annual Report 2001-2002

Canada



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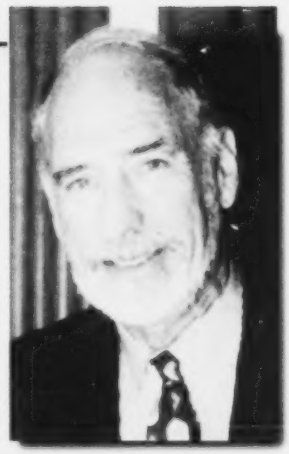
Message from *the Minister*



As Canadians, the weather is the fabric of our lives. With its vast size, varied terrain, abundant lakes and rivers, and seasonal extremes, Canada experiences a broad diversity of weather and climate conditions. Environment Canada's Meteorological Service of Canada (MSC) operates 24 hours a day, seven days a week, to forecast these conditions from coast to coast to coast, and to provide warnings of severe weather to the public.

The MSC Annual Report 2001-2002 demonstrates the importance of the MSC's work to reduce risks to Canadians from weather-related environmental hazards such as storms, tornadoes, smog, ultraviolet rays, icy roads and wind chill. It supports other federal departments, such as Health, National Defence and Fisheries and Oceans, in their efforts to safeguard Canadians from environmental emergencies. It also provides the Government with scientific information to support the development of effective policies on key issues, such as clean air, clean water and climate change.

The MSC is also key to the economic growth and prosperity of our nation. Weather-sensitive industries, such as transportation, energy, construction, forestry, fisheries, agriculture, tourism and recreation, contribute approximately $150 billion annually to Canada's economy. The MSC helps these industries improve productivity and competitiveness by providing access to high-quality, timely and reliable weather, water, ice, and climate information, and by supporting the private meteorological sector in developing customized services and products.

In order to produce this information, the MSC employs highly trained staff, works with public and private sector partners to advance weather and climate research, uses sophisticated technology such as supercomputers, satellites, radars and ocean buoys, and cooperates in international climate studies. All of these endeavours are guided by a commitment to excellence in service and science.

I am proud of MSC's contribution in making Canada the country it is today and I am excited by its future as it keeps enhancing the quality of our lives.

David Anderson

The Honourable
David Anderson, P.C., M.P.

Ottawa, Ontario

Foreword from

the Assistant Deputy Minister

Information about weather and climate is essential to the health, safety and prosperity of Canadians. Accurate and timely information allows individuals to make decisions about daily activities and enables weather-sensitive businesses to make plans that will help their economic growth.

The Meteorological Service of Canada (MSC) ensures that Canadians have access to up-to-date weather and climate conditions. The MSC provides weather forecasts and warnings, and information on ultraviolet rays, air quality and wind chill. We also monitor the quantity of water in lakes and rivers, and forecast ice and wave conditions for marine transportation. Behind this information lie a vast array of partnerships, research, science and technology, and a knowledgeable and dedicated staff that keep Canada on the forefront of weather and climate science.

During 2001-02, we signed new agreements with NAV CANADA to continue providing aviation weather services, and with Pelmorex Inc. to enhance access to data for the Weather Network and Météomédia. We provided customized weather products to our Canadian military involved in Operation APOLLO in the Arabian Sea and Afghanistan. We also built new links with and identified business opportunities for the emerging private meteorological sector.

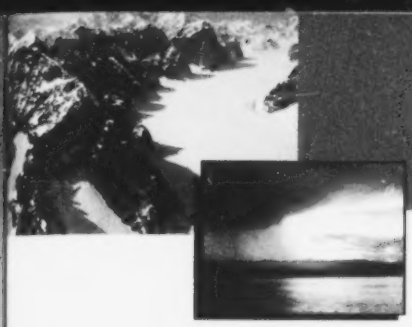
On September 11th, the MSC ran dispersion models to assess the movement of polluting substances from the City of New York. We also responded to a request from the US Environmental Protection Agency (EPA) to provide air sampling filters to assist U.S. EPA scientists with air monitoring at or near Ground Zero.

The improvement of our analysis and modelling systems has led to significant changes to Canada's operational forecast guidance products. For these changes, MSC received international recognition.

The MSC is a results oriented organization that strives to provide Canadians with the best possible services to protect their health and safety. Since 1871, the MSC has continuously adapted to scientific and technological change to meet the needs of Canadians both today and tomorrow.

We know that change and innovation are essential to staying on the cutting edge of meteorology. To that end, we are recruiting new professionals, modernizing equipment and investing in innovative technologies, such as Doppler radars. This is an evolving process that will take some time, but we are committed to continuing our long tradition of excellence in serving Canadians.

Marc Denis Everell



I. Who We Are

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Canada's national weather service was established in 1871, and its water survey activities were first officially recognized in 1908.

After World War II, the need for weather information for aviation purposes expanded, and the weather service came under the management of the Department of Transport.

In 1971, meteorological and hydrological functions were transferred to the newly created Department of the Environment.

In 1999, the Meteorological Service of Canada (MSC) was designated a Departmental Service Organization within Environment Canada, with responsibility for weather prediction, weather warnings, the national water survey, the ice service, and the science of climate and air quality.

Meteorological Service of Canada — NATIONAL HEADQUARTERS ORGANIZATIONAL CHART

Alan Nymark
Deputy Minister
Environment Canada

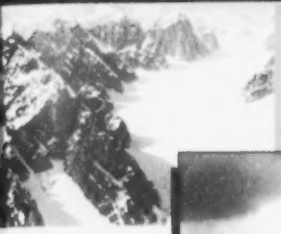
Marc Denis Everell
Assistant Deputy Minister
Meteorological Service of Canada

Regional Directors General

Directors MSC Regions
Quebec Region
Ontario Region
Atlantic Region
Pacific & Yukon Region
Prairie & Northern Region

Corporate Advisors
Finance & Administration
Human Resources
Communications

ATMOSPHERIC MONITORING AND WATER SURVEY	ATMOSPHERIC ENVIRONMENT PREDICTION	ATMOSPHERIC AND CLIMATE SCIENCE	SERVICES, CLIENTS AND PARTNERS	POLICY AND CORPORATE AFFAIRS
National Weather and Climate Network	National Prediction Programs	Associate Director General Climate Change	National Resource Sector Services	Business Planning & Development
National Radar Project	CMC – Operations	Air Quality Research	Aviation and Defence Services	Policy and International Affairs
National Weather and Climate Operations	CMC – Informatics	Climate Research	Ice and Marine Services	Strategic Capital Planning
Data Standards and Quality Management	CMC – Development	Meteorological Research	Meteorological Services and Business Policy Branch	Special Projects
Water Survey		Adaptation and Impacts Research		
National Archives and Data Management		Science Assessment		



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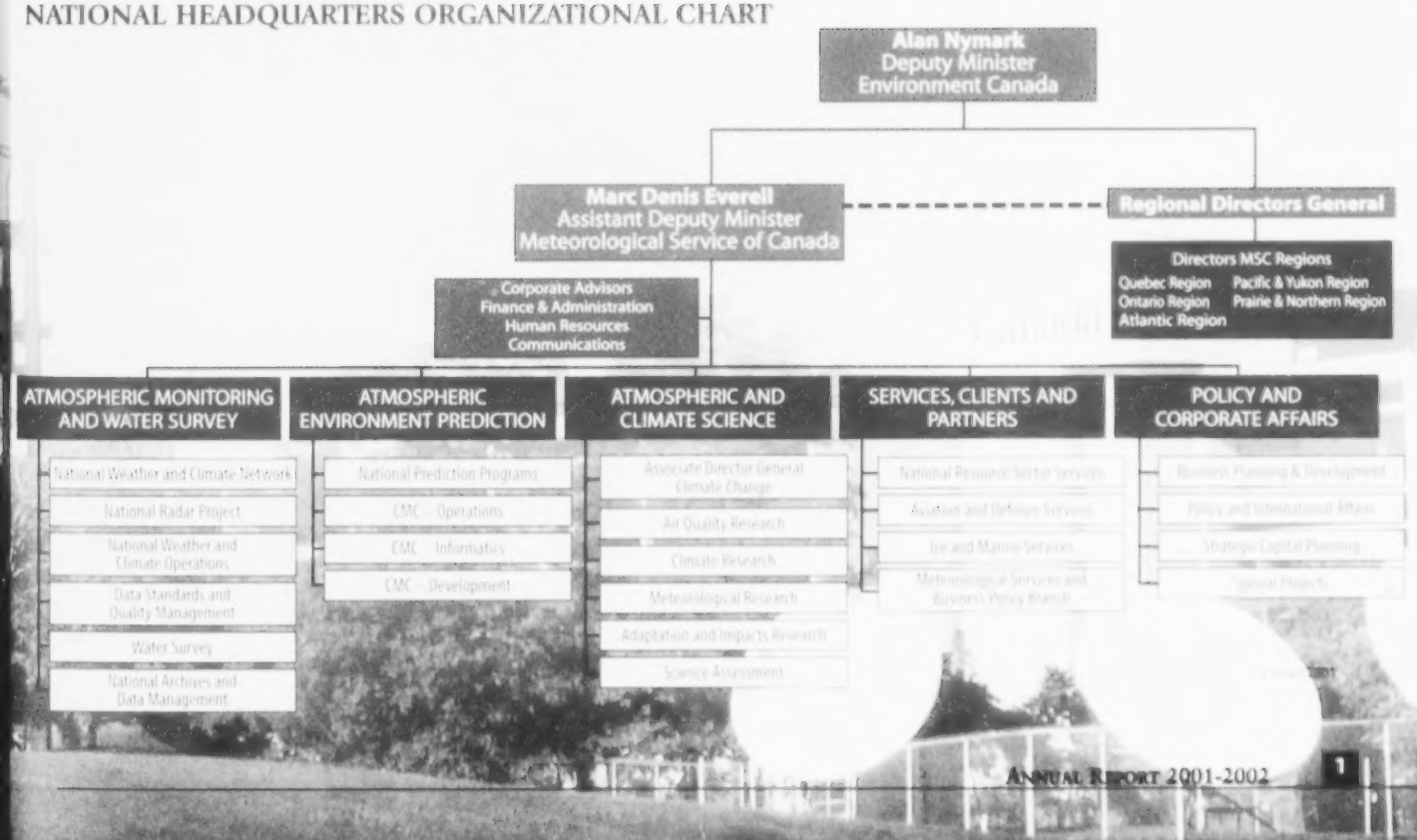
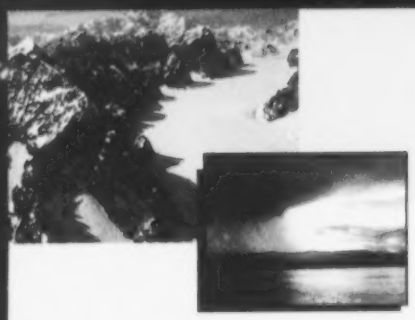




The MSC is a vital component of Environment Canada's efforts to provide services and science that promote the health, safety and economic well-being of Canadians. Its programs are delivered through the Department's five regions, as well as through MSC offices in Toronto (Ontario), Montreal (Quebec), the National Capital Region and through institutions such as the University of Victoria, University of British Columbia and the University of Toronto.

OUR PEOPLE

MSC staff are highly trained and specialized scientific and technical workers. Many work round-the-clock shifts on land and at sea in locations across Canada—including the High Arctic—to monitor and predict weather and to measure water levels of major lakes and rivers. Its dedicated staff are the primary reason the MSC is recognized internationally for world-class weather prediction services and excellence in atmospheric science research.

Meteorologists discuss air quality information

FACTS ABOUT THE MSC

- The MSC is one of the most sophisticated weather and hydrometric services in the world, with a $375 million technological infrastructure that operates 24 hours a day, 365 days a year. This infrastructure involves everything from traditional tools, such as rain gauges and thermometers, to state-of-the art supercomputers, Doppler radars, and satellite receivers.

Automatic Voluntary Observing Ship (AVOS) System bridge, PC and touchscreen monitor installed on ship bridge.

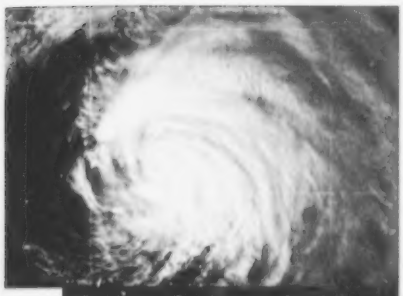
- A research laboratory and a large component of the MSC's national headquarters are located in Toronto. Weather centres in MSC's five regions provide weather forecasts and warnings, and other offices across Canada provide specialized client services or conduct research.

Canadian Ice Service Aircraft

- The Canadian Ice Service, located in Ottawa, conducts ice surveillance and forecasting for the Arctic, the Eastern Canadian seaboard, the St. Lawrence, and the Great Lakes.

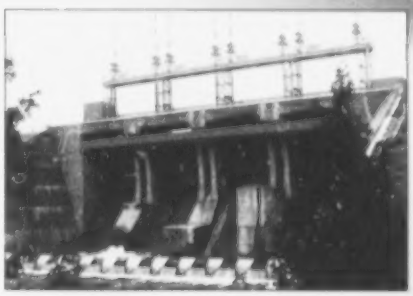
MSC Supercomputer

- The Canadian Meteorological Centre (CMC) in Montreal is the hub of national telecommunications, weather-modelling, and emergency-response services. The CMC's computers handle about three trillion bytes of data per day, and include one of the fastest scientific supercomputers in the world. The supercomputer supports the production of forecasts, weather research and climate modelling activities.
- More than 100 years of climate data, representing seven billion observations, are stored in the MSC's archives for use by researchers, the media, and clients such as insurance and law firms.



Hurricane Gert approaching the Avalon Peninsula of Newfoundland

➤ The Canadian Hurricane Centre (CHC) in Dartmouth, Nova Scotia, is part of the Maritimes Weather Centre. The CHC gathers information on tropical and post-tropical cyclones, predicts the evolution of these storms, and assesses and forecasts their potential impacts on Canadian territory. The Centre's area of forecast responsibility covers all Canadian territory, including Ontario, Quebec and the Atlantic Provinces and; Canadian waters out to the 200 nautical mile limit.



➤ The Water Survey of Canada and its partners measure river flow and record the levels of lakes and rivers at more than 3100 locations in Canada. Historical records from 7700 sites estimate streamflow at ungauged locations. The MSC's hydrometric network is being modernized to, among other things, better assist the Provinces in flood prediction and prevention.

THE MSC ADVISORY BOARD

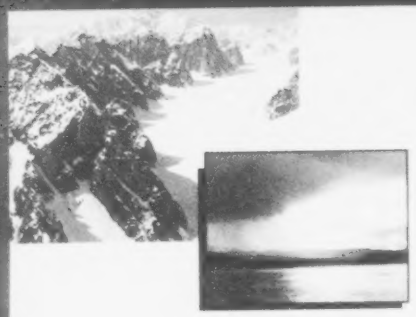
The MSC receives guidance from the Advisory Board on meteorological services—a body made up of senior executives from various stakeholder and client groups. The Board's purpose is to: provide client-focused advice to the Assistant Deputy Minister on MSC programs and priorities; review technical reports concerning MSC activities and their relationship to other parts of Environment Canada and to stakeholders; and, promote co-operative programs involving the MSC among potential partners in the private sector, other federal departments, universities, and provincial agencies.

FIRST ROW (seated): **David Grimes** *(MSC, Environment Canada)*, **Allan Jeffrey** *(Canadian Interagency Forest Fire Centre)*, **Pierre Morrissette** *(Pelmorex)*, **Marc Denis Everell** *(MSC, Environment Canada)*, **Phil Duffield** *(Ontario Provincial Police)*

SECOND ROW (standing): **Samuel Scully** *(Dalhousie University)*, **Andy Vasarins** *(NAV CANADA)*, **Robert Friesen** *(Canadian Federation of Agriculture)*, **David Egar** *(Environment Canada)*, **Sonny MacDonald** *(Fort Smith, Nunavut Territory)*, **Marc Dumais** *(Department of National Defence)*, **John ApSimon** *(Environment Canada)*, **Paul Kovacs** *(Insurance Bureau of Canada)*

ABSENT: **John Mills** *(Environment Canada)*, **Richard Cavanagh** *(Canadian Association of Broadcasters)*, **Ashkon Hashemi** *(Canadian Federation of Students)*, **Azzah Jenna** *(Federation of Canadian Municipalities)*

The Board met three times between May 2001 and February 2002, during which time it provided a great deal of useful information and guidance. Its members are engaged in the issue of the MSC's future, and offered sound advice in discussions on key performance indicators and initial reactions on a report on MSC's relationship with the private meteorological sector in Canada. The role of the Board is evolving, and the MSC looks forward to its continued contribution.



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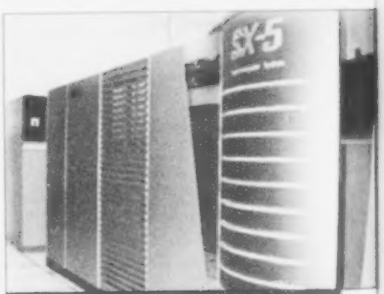

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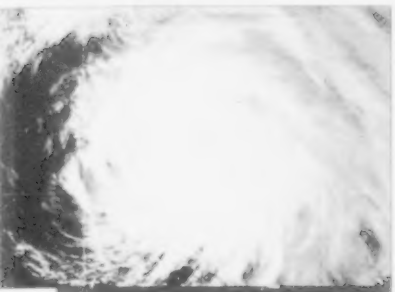

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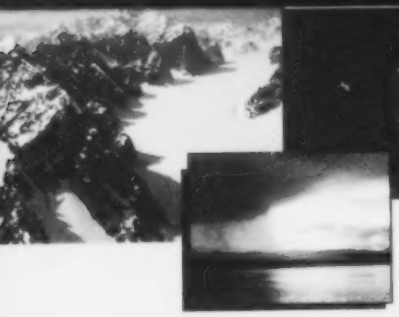


II. What We Do

Taking a rain gauge measurement

The Meteorological Service of Canada:

- provides weather forecasts and warnings of high-impact weather events and, together with the provinces, produces information on hazardous air quality;
- monitors atmospheric conditions and the quantity of water in Canadian lakes and rivers;
- forecasts ice and wave conditions on navigable oceans and inland waters;
- monitors and predicts the state of the climate;
- leads the development of atmospheric science and related environmental prediction in Canada; and,
- is Canada's primary source of weather warnings, and the principal scientific authority for standards, information and advice on the past, present and future states of the atmosphere, hydrosphere (lakes, rivers and oceans) and cryosphere (snow and ice).

Serving Canadians

Weather services are among the most frequently used federal government services. Polls show that virtually all Canadians surveyed (92 per cent) listen to at least one weather forecast daily.

Annually, the MSC issues approximately 14 000 severe weather warnings and 3500 ice hazard warnings, and provides about 500 000 public weather forecasts, 200 000 marine weather forecasts and 400 000 aviation forecasts.

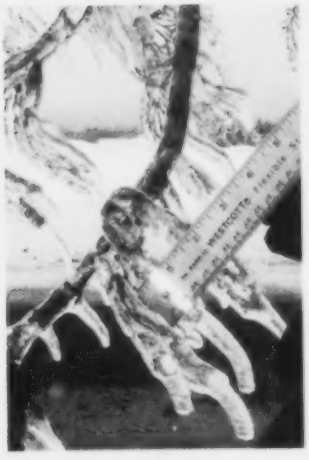
The mass media are our primary means of reaching Canadians, and are vital to ensuring that Canadians receive weather information (especially warnings) in a timely manner.

Weather information can also be accessed via the following Environment Canada dissemination systems:

- **Weatheradio:** bilingual weather information is continually broadcast over Weatheradio VHF frequencies.
- **Internet:** visits to MSC's weather web pages at weatheroffice.ec.gc.ca are increasing at a rate of 12 percent per month. During the last quarter of 2001-02, the MSC weather site received 600 million hits corresponding to 75 million pages viewed during 19 million visits.
- **Telephone:** free recorded messages provide basic public forecasts, and a 1-900 user-pay phone service enables callers to speak directly to a meteorologist 24 hours a day.

Serving Others

The MSC provides scientific services and information to others, such as, the media, other government departments (eg. Department of National Defence), research institutes, and businesses such as the private meteorological sector, agriculture, construction and transportation interests.



Monitoring

Data are critical to the environmental prediction process. In Canada, information on weather, air quality, ice, snow and water are gathered through an array of observation networks—some based on the ground or in water, and others operating from the upper atmosphere and space.

III. HIGHLIGHTS OF 2001-2002

1. SAFETY FROM ENVIRONMENTAL HAZARDS

One of the MSC's key goals is to reduce Canadians' risk from weather-related environmental hazards. In addition to providing over 14 000 severe weather warnings annually, the following are examples of specific work undertaken during 2001-02 to safeguard the health and safety of Canadians.

Emergency Response

Shortly after the terrorist attacks of September 11, the Canadian Meteorological Centre's (CMC) Operations Branch provided specialized numerical guidance to Health Canada on the long-range atmospheric transport and dispersion of plumes from the attack locations. Health Canada's request was made in the context of the potential presence of radioactive or other hazardous substances on board the aircraft used in the attacks, and the impact such a scenario would have on Canada. Results of the numerical simulations indicated that it was unlikely that any released material would affect Canadian territory within 72 hours. The CMC's response fell within its mandate as a member of the Technical Advisory Group under the Federal Nuclear Emergency Plan.

Satellite observation of the smoke and dust plume out of New York City on September 12. The lines are depicting the atmospheric trajectories scenario at various heights above ground as computed from CMC Emergency Response systems.

Operations Branch received the Head of the Public Service Award 2001 for its specialized operational support to the response.

National Radar Network

The MSC's network of conventional and Doppler radars covers 95 per cent of Canada's population. Under the MSC's multi-year National Radar Project, all weather radars will be converted to Doppler to improve the detection and prediction of environmental hazards, such as severe weather and floods.

The installation of six new Doppler radars in 2001-02 brings the national total of new radars to 19, leaving only 11 to be completed in the remaining two years of the project. The new radars were installed at Strathmore (Alberta); Landrienne, Villeroy and Val d'Irène (Quebec); Halifax (Nova Scotia); and Marble Mountain (Newfoundland). Work on the Marion Bridge radar in Cape Breton was delayed by legal issues, but is now in progress.

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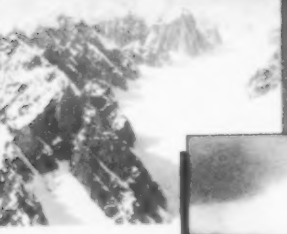

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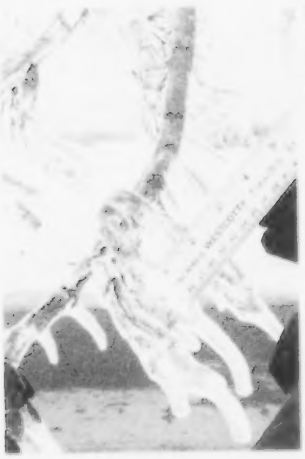

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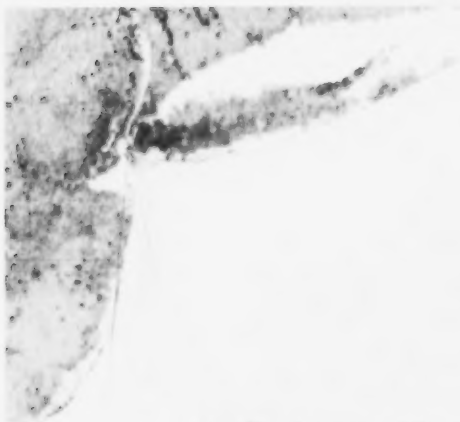

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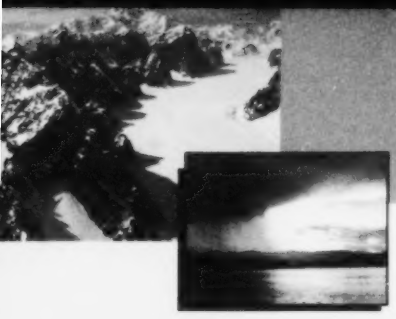
Operations Branch received the Head of the Public Service Award 2001 for its specialized operational support to the response.

National Radar Network

The MSC's network of conventional and Doppler radars covers 95 per cent of Canada's population. Under the MSC's multi-year National Radar Project, all weather radars will be converted to Doppler to improve the detection and prediction of environmental hazards, such as severe weather and floods.

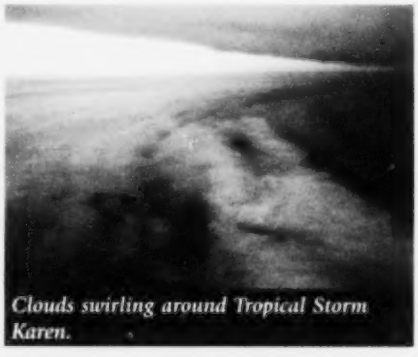
Radar Implementation Schedule

The installation of six new Doppler radars in 2001-02 brings the national total of new radars to 19, leaving only 11 to be completed in the remaining two years of the project. The new radars were installed at Strathmore (Alberta); Landrienne, Villeroy and Val d'Irène (Quebec); Halifax (Nova Scotia); and Marble Mountain (Newfoundland). Work on the Marion Bridge radar in Cape Breton was delayed by legal issues, but is now in progress.



The Canadian Hurricane Centre

During the 2001 hurricane season (June 1 to October 31), the CHC issued 110 bulletins and had six tropical cyclones enter its response zone. This made 2001 the third consecutive season to see tropical cyclone activity of this level or higher, and brought the annual average over the past seven years to 5.7.



Clouds swirling around Tropical Storm Karen.

Air Quality Forecasts

- In April 2001, the MSC hosted Canada's first National Workshop on Air Quality Prediction and Applications in Fredericton, New Brunswick. Nearly 160 meteorologists, scientists, chemists, lung-association members and media from across Canada, the United States and Mexico exchanged information on air quality forecasting, monitoring and research.
- In May 2001, Air Quality Research Branch (AQRB) and the Canadian Meteorological Centre (CMC) implemented a National Air Quality Prediction Program in Canada. The program provides numerical/chemical model guidance to provincial agencies and Environment Canada regions that produce daily air quality forecasts for the public. The forecasts are available via radio, television, and Environment Canada's Weather Office Web site. Many regional forecasting initiatives also took place during 2001-02 involving provincial ministries and local municipalities.

AIR QUALITY PREDICTION PROGRAM
June 1, 2001: Air Quality Prediction Program for British Columbia's Lower Fraser Valley developed, issuing first publicly accessible air quality forecast on June 1, 2001.
August 2001: Pilot Ventilation Index (VI) forecast issued daily by e-mail for eight locations, proving useful in helping to avoid high-local concentrations.
May 2001: Smog Prediction Program re-launched in three Maritime provinces.
January-March 2002: Air dispersion pilot project run for Saint John and Fredericton, New Brunswick.
Pacific & Yukon
Prairie & Northern
Ontario
Quebec
Atlantic
Continued to support the provincial air quality forecast and warning program.
November 21, 2001: Daily Winter Info-Smog air quality prediction program for the Greater Montreal Region launched.
Summer Info: Smog program extended in its ninth year to cover all of the Gatineau-Quebec City corridor.

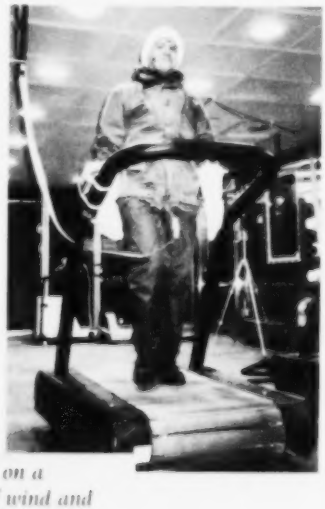
- In a cooperative venture with the U.S. Environmental Protection Agency, the MSC launched the real-time ground-level ozone mapping program, which operates from May to September. MSC-Atlantic collects data from the six eastern Canadian provinces for input into the on-line site at www.epa.gov/airnow/canadamapl.html.

Severe Weather Preparedness, Education and Awareness

Several MSC regions held severe summer and winter weather awareness weeks in order to help the media and the public prepare for the upcoming seasons' high-impact weather. Activities in Prairie and Northern Region were coordinated by the Prairie Storm Prediction Centre in Winnipeg, while MSC Atlantic joined forces with the Office of Critical Infrastructure Protection and Emergency Preparedness and provincial emergency measures organizations.

Renewed Wind Chill Program

Wind chill can play a major role in cold-weather health hazards because it speeds the rate at which the body loses heat. For many years, scientists have worked to improve a mathematical formula that relates air temperature and wind speed to the cooling sensation felt on skin. The lack of a standard way of reporting wind chill, even within Canada, has also led to some confusion. Public surveys conducted by the MSC have shown the importance and utility of wind chill information to the public and media.



Physiological trials being conducted on a volunteer to determine the effects of wind and temperature on exposed skin.

During 2001, a team of Canadian and American scientists and medical experts collaborated to create a new wind chill index based on the loss of heat from the face. The new index is expressed in temperature-like units that liken the way skin feels to the temperature on a calm day.

The MSC launched the new wind chill index in fall 2001, and implemented a public-education program to raise awareness and understanding of the new system. Local forecasts are available through radio and TV broadcasts, as well as on Environment Canada's Weatheradio, recorded telephone messages, and web site.

2. PARTNERSHIPS

The MSC works with partners in almost everything it does. Research and development is conducted with universities, research institutes and the private sector, both nationally and internationally. Partners such as the media and the provinces are essential in the delivery of services to protect the public from environmental hazards and the promotion of educational and outreach activities. The MSC also works with other services within Environment Canada, other government departments and international organizations to develop assessments and policies to protect and conserve our natural environment.

NAV CANADA

Renewed Agreement

Since 1996, MSC personnel have provided a broad range of weather services in support of civilian aviation under an agreement with NAV CANADA—the not-for-profit corporation that operates the national Air Navigation System. A stipulation of NAV CANADA's creation was that it contract the MSC for these services for the first five years of its existence, after which time it would be free to pursue other options.

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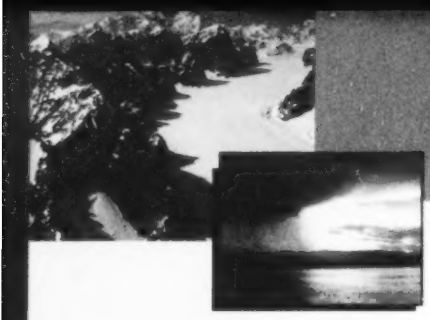

Negotiations for a new agreement took place over the year leading up to November 2001, when the first agreement expired. On December 1, 2001, a new 10-year agreement came into effect that retains most of the work covered in the original agreement, and ensures that MSC will continue to be involved in the provision of weather services to aviation.

Aviation Weather Web Site

In response to the popularity of the Canadian aviation weather web site pioneered by MSC Quebec, the Canadian Meteorological Centre (CMC) was tasked with creating an Aviation Weather Web Site (AWWS) that would be fully integrated into NAV CANADA's Flight Services Strategy and housed at the CMC. Since the launch of the new site in spring 2001, its daily hits have increased from 2000 to over 17 000. Clients can access the site at pilot-information kiosks in airports across Canada, and via the Internet. The CMC is developing the site's capability to include access to NOTAMs (general NOTice to AirMen of situations affecting aerodrome operations), flight plan filing, and new Automated Supplementary Enroute Weather Predictions—a Web interface that allows users to input flight-plan parameters and receive graphical weather forecasts that are tailored to their route.

Nav Canada Flight Services Specialist using Weather Graphics System provided by MSC

Department of National Defence

Over 80 MSC personnel provide customized weather and oceanographic services to the Department of National Defence (DND) from dedicated offices operating under a recently-renewed Memorandum of Understanding and Service Provision Arrangement.

The MSC has provided extensive meteorological support to Operation APOLLO—Canada's contribution to the military response to the terrorist events of September 11, 2001. Weather Services Centres (WSCs) in Halifax and Comox supplied mesoscale forecasts to navy ships on route to the Arabian Sea, while WSC Greenwood prepared daily weather products to military commanders and planners across Canada. WSC Trenton has prepared climatological summaries for Afghanistan, with additional detail for the provinces of Kabul and Parwan provinces, and neighbouring countries. The Canadian Meteorological Centre has used its numerical weather prediction model to provide upper-level wind and temperature forecasts.

In spring 2001, the MSC launched the Canadian Forces Weather Office web site. The site gives DND personnel across Canada and around the world access to weather observations and forecasts, radar and satellite data and other customized weather products over the Defence Wide Area Network and through protected dial-in access.

Canadian Coast Guard

Over 25 000 products were issued, 144 000 deliveries made, and 775 telephone requests and 455 e-mail messages answered by the Canadian Ice Services (CIS) in 2001-02. This represents an increase in all areas over the previous year, with e-mail growing the greatest at 32 percent. Since 2000, when the CIS launched a major effort to encourage time-dependent clients to use on-line access to information, Internet subscriptions have increased eight-fold.

The CIS ice-reconnaissance aircraft flew 162 missions in support of the Canadian Coast Guard ice-breaking activities, logging some 172 000 kilometres over Canada's east coast and the Arctic. Ice Service Specialists spent 1523 days providing front-line ice information and advice to captains on Coast Guard icebreakers and in regional ice offices.

Provinces and Territories

Many provinces and municipalities are installing hi-tech Road Weather Information Systems (RWIS)—automated weather stations located adjacent to roadways and equipped with built-in pavement sensors—to help prevent accidents involving snow and ice. The data from these systems enable meteorologists to produce accurate forecasts of road surface temperatures and conditions. This, in turn, allows road maintainers to improve safety and reduce salt usage by treating roads in advance.

The provinces and territories are seeking assistance from Transport Canada and Environment Canada in implementing a national RWIS network. In February 2002, the MSC hosted a Road Weather Symposium that brought together participants from within the Service, along with members of the transportation and private meteorological sectors. The symposium resulted in the formation of a Road Weather Coordination Committee to support the implementation of road weather systems and services in Canada.

Media

The media are key partners in getting the MSC's warnings and forecasts out to Canadians. They also assist in disseminating information on how Canadians can protect themselves and their property from environmental hazards and longer-term adaptation strategies.

The MSC signed a new contract with Pelmorex Inc. to provide the company's specialty television services—the Weather Networks and Météomédia—with better access to data and products at a lower cost. The agreement also raises Environment Canada's visibility by giving increased attribution in Pelmorex broadcasts.

Private Meteorological Sector

The private meteorological sector in Canada is small, but diverse. The MSC is working to build stronger relations with this sector, and to encourage the development and use of value-added meteorological services. These services will benefit all Canadians, as $150 billion of our nation's economy is weather-sensitive. In addition to responding to the strategic needs of the private meteorological sector and identifying areas where it can play a supporting or cooperative role, the MSC is working to improve data access and identify new and emerging business opportunities for this sector.

In 2001-02, the MSC participated in a private-sector-led task force of the Canadian Meteorological and Oceanographic Society (CMOS) and the creation of an industry strategy for the development of the private meteorological sector. The MSC is considering the task force's recommendations in its review of ways to remove barriers to private-sector development and focus its own services on core responsibilities. It will respond with specific actions in 2002-03.

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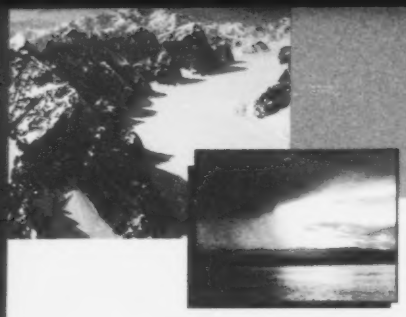


Universities and Research Institutes

The MSC cooperates with universities and research institutes in Canada and around the world to conduct research on atmospheric and environmental science, and to develop policies on issues such as climate change. Some MSC scientists are co-located in universities to serve as adjunct professors, and to foster increased synergy between government and academic research. The following are examples of partnerships that took place in 2001-02.

Research Funding

Canada is particularly vulnerable to climate change, severe-weather events, and the deterioration of air quality in its urban centres. To help fund research in these critical areas, the Government of Canada awarded a $60-million one-time grant in March 2000 to create the Canadian Foundation for Climate and Atmospheric Sciences (CFCAS). In 2001-02, working with CFCAS partners in government, universities and the private research sector, the MSC was involved with successful submissions on research proposals that will advance scientific knowledge in a number of key areas of concern to Canadians.

Ten major initiatives received funding, including:

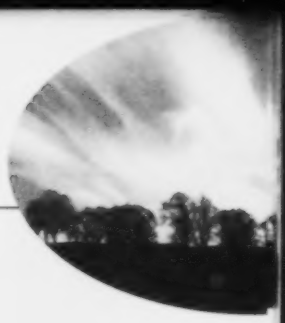
- The Canadian Surface Ocean Lower Atmosphere Study (SOLAS), an international research initiative being led by Dalhousie University in Halifax, Nova Scotia, that will address key interactions in the marine biogeo-chemical system and how this system affects and is affected by past and future climate and environmental changes. MSC scientists are participating in an ocean fertilization experiment that will provide insight into the impact of dimethyl sulphide production (a source of particulate sulphates), on the atmospheric aerosol and cloud reflectivity, and ultimately, on the effects on the regional climate;
- The Multi-scale Air Quality Modelling Network (MAQNet), an effort headed by Toronto's York University to form a collaborative network of academic and government researchers aimed at furthering air quality modelling in Canada, and at producing both skilled air quality scientists and a readily useable product for the MSC's Air Quality Prediction Program; and,
- Pacific 2001, air quality field measurements by York University were part of a MSC led field study to provide information for model evaluation and better describe the production of smog in British Columbia's Lower Fraser Valley. Canada's university community played a key role in planning and implementing the study by providing knowledge and techniques to supplement efforts by MSC scientists. Another positive outcome of the study has been a strengthened partnership between university and government scientists, leading to potential future collaborative studies elsewhere in Canada.

BERMS Project

A number of studies were carried out under the Boreal Ecosystem Research and Monitoring Sites (BERMS) program, which is co-led by the MSC, the Canadian Forest Service and Parks Canada, with significant

Primary (Mature) BERMS Sites

Old Aspen (Deciduous)	Old Black Spruce (Wet Coniferous)	Old Jack Pine (Dry Coniferous)



participation from the University of British Columbia, Queen's University, McMaster University and the University of Wisconsin. Created in 1997, BERMS focuses on the role of Canada's boreal forest in the global carbon cycle and climate change.

Recent data from the program suggests that spring temperature may be the key factor influencing the ability of Canadian forests to sequester carbon from the atmosphere. This information will contribute to increased confidence in predictions of climate change by improving our ability to model the carbon and water cycles of the boreal forests that dominate our landscape.

Extreme-Weather Research

Government, industry and universities have joined forces to ensure that Canada maintains a high level of expertise in the area of extreme weather, and that sectors work closely with one another to address this national concern. The following are examples of these efforts.

- LUTE (Laboratoire universitaire sur le temps extrême) is a collaboration between the MSC and the Network for Computing and Mathematical Modelling—a network of eight Montreal-based research centres and their industrial partners. The objective of the laboratory is to coordinate and promote research and cooperation in the area of atmospheric sciences (extreme weather in particular), and to ensure the training of personnel.
- The Institute for Catastrophic Loss Reduction and the MSC have committed partial financial support for the creation of the McGill University Chair in Extreme Weather—a new position in the Department of Atmospheric and Oceanic Sciences.

Other Partnership Activities

Agriculture and Agri-Food Canada

The MSC works closely with Agriculture and Agri-Food Canada (AAFC) on several fronts. In 2001-02, the MSC's Atmospheric Monitoring and Water Survey Directorate provided a series of precipitation data to the Prairie Farm Rehabilitation Administration to create a drought map of Canada. Last year, in collaboration with the Ontario Ministry of Agriculture, Food and Rural Affairs, the MSC and the AAFC broadened their research on diamondback moth infestations to also include eastern Canada. Trajectory forecasts of invasive species, made using the MSC's Global Environmental Multiscale model, allow farmers to assess risks and take appropriate measures. The program will continue in 2002-03 – with the addition of a new partner, the Ministère de l'agriculture, des pêcheries et de l'alimentation du Québec.

Specialized Forecasts for Partners in British Columbia

In addition to dealing with the daily challenges of weather forecasting in a region affected by mountains and ocean, meteorologists at the Pacific Weather Centre provided critical specialized information to clients during 2001-02. This included developing and issuing wind and gust forecasts to site engineers while the deck of the Lion's Gate Bridge in Vancouver was being replaced and the structure was vulnerable to collapse. The Centre also developed and issued rainfall-rate forecasts while repairs were being made to underwater sections of Vancouver's Cleveland Dam. In order to carry out the repairs, the water level of the Capilano Reservoir had to be lowered and a platform built to hold heavy construction equipment—a situation that could have been jeopardized by a sudden increase in river flow. In both cases, the Centre contacted the project engineers if conditions were expected to exceed pre-determined thresholds.

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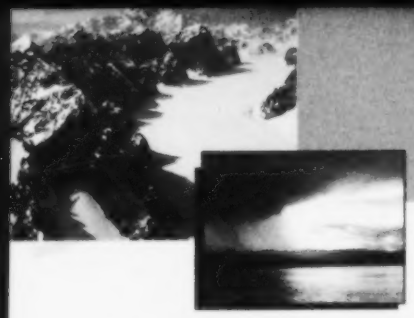


Cooperative Meteorological Research Network in Quebec

In early 2002, the founding members of the Quebec Cooperative Meteorology Network—Environment Canada, le ministère de l'Environnement du Québec (Quebec Ministry of Environment), Hydro-Québec, la Société de protection des forêts contre le feu (Forest Fire Protection Society), le ministère des Ressources naturelles du Québec (Quebec Ministry of Natural Resources) and Alcan—signed a collaborative agreement to share data observations and expertise. The Network includes some 300 meteorological stations—125 of which are managed by the MSC, and 200 traditional climate stations run by the ministère de l'Environnement du Québec in partnership with Environment Canada. Its goal is to improve the quality of meteorological observations in Quebec, and thus assist all partners in their endeavours.

3. ADVANCES IN SCIENCE

The MSC conducts research to ensure that Environment Canada has a solid scientific foundation on which to build policies and strategies that safeguard our environment and protect human health. During the past year, scientists and other staff in MSC regions and headquarters carried out research in a wide variety of areas related to climate change, air quality, weather research and water. They also published reports and articles, and conducted scientific presentations and media interviews in a variety of fields. Following are some examples.

External Peer Review

A panel of atmospheric and climate scientists and managers from the United Kingdom, the United States, Australia and France conducted an external review of MSC's research and development program to evaluate performance and improve decision-making on departmental resources and planning. The review included an assessment of the productivity, quality and relevance of the MSC's science, the impact of its results on services and policy development, and future directions.

The Panel concluded that the MSC is a world leader in many areas of atmospheric and climate science, and that its research and development program "is fundamentally sound and responsive to the needs of Environment Canada and the Canadian citizens." The Panel's observations and recommendations were provided to senior management in a 25-page report, available on the MSC web site (www.msc-smc.ec.gc.ca). Some specific areas recommended for action were: personnel succession planning; an ongoing peer review process; increased university collaboration; better client interactions; and a strategic science plan. Plans are being developed to address these areas.

Weather Research

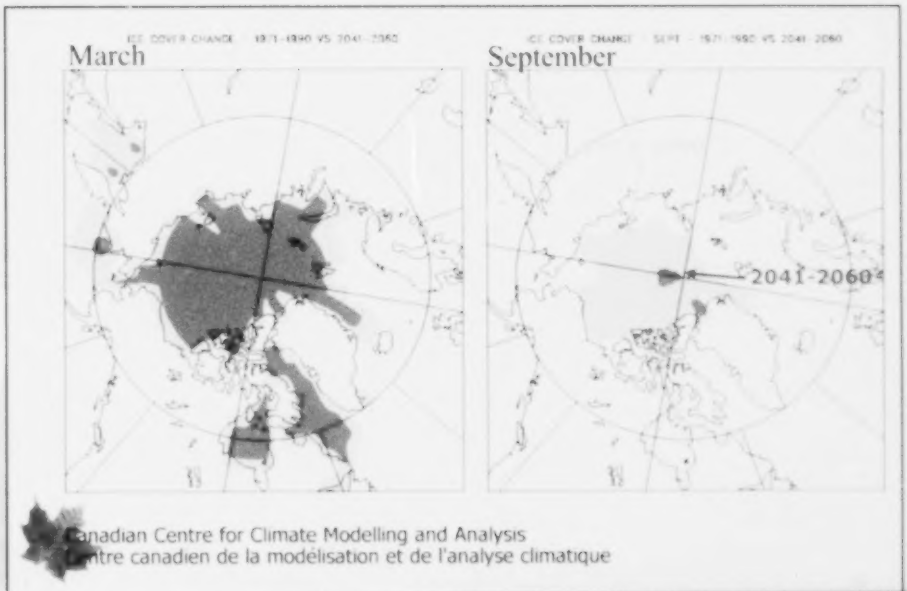
Research Flight into Tropical Storm Karen

The MSC participated for the second time in a joint project with the National Research Council to fly a Convair 580 research aircraft into a tropical cyclone (the first was Hurricane Michael in 2000). The crew flew into Tropical Storm Karen on the morning of October 15, 2001, collecting data on wind, humidity, temperature, pressure, and micro-physical cloud measurements.

The resultant data—the first ever to document the structure of tropical cyclones—will be used for a CFCAS-supported research project and other collaborations with Canadian universities, and to better enable numerical weather prediction models to predict the behaviour of these systems. Such studies will improve forecasts of the movement and intensity of tropical systems, which will lead to more timely and effective warnings for Canadians.

Climate Change Research and Modelling

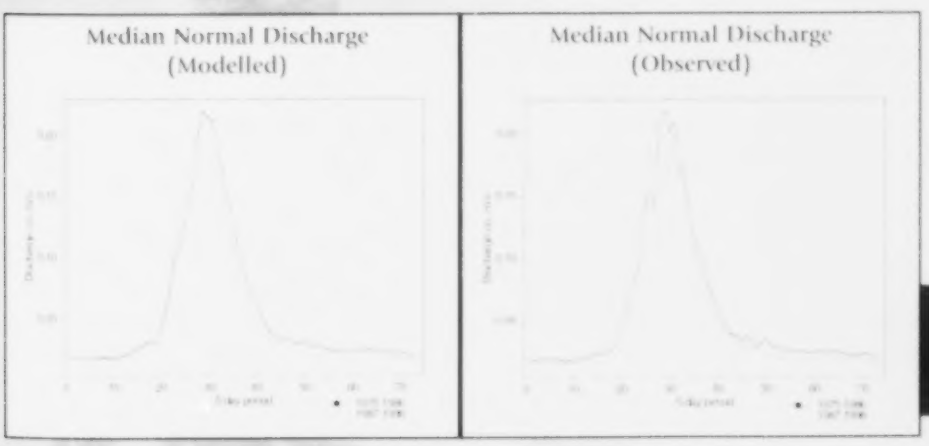
Canada has experienced 19 consecutive seasons with above-normal temperatures, a trend that has occurred globally for the last 23 years. Studies using the MSC climate model consistently find evidence of a human-caused signal in global temperature observations, and research is underway to determine whether such a signal exists on a continental scale.



This is a spatial illustration of ice cover change projected by the Canadian Centre for Climate Modelling and Analysis (CCCma) model. The light color indicates ice cover over the 1971-2000 period, the dark color is for 2041-2060. The left panel is March; the right panel is September. The CCCma model projects essentially ice-free Arctic in summer by the middle of the century. Projected changes in sea-ice cover are especially worrisome, and have potentially important consequences for transportation, Arctic ecosystems and indigenous people.

Hydroclimatic Variations in BC and Yukon Watersheds

Climate change can have significant effects on water resources in Canada, including the availability of water during the annual water cycle, and the severity of extreme events such as droughts and floods. During recent decades, hydrologic changes in natural streamflow systems in British Columbia and the Yukon have shown a strong climate signal—with streams in the interior of BC exhibiting an earlier spring freshet and extended summer recession, and streams in the Yukon having significantly higher flows throughout the year. The MSC is using a combination of statistical and process-based models to generate hydrologic-change scenarios and to determine the mechanisms responsible for recent hydroclimatic variability.



Simulated discharges at Sullivan Creek near Revelstoke for periods 1975-1986 and 1987-2000 as modelled (left) and observed from hydrometric stream data (right)

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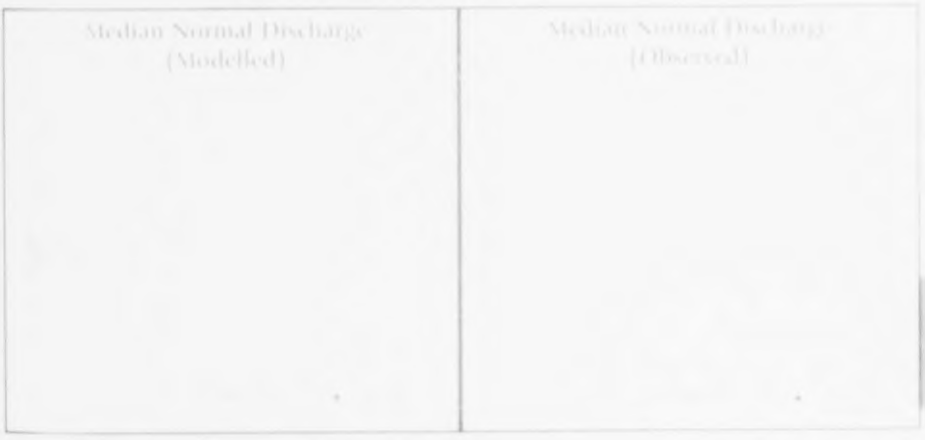
Canada has experienced 19 consecutive seasons with above-normal temperatures. A trend that has occurred globally for the last 23 years. Studies using the MSC climate model consistently find evidence of a human-caused signal in global temperature observations, and research is underway to determine whether such a signal exists on a continental scale.

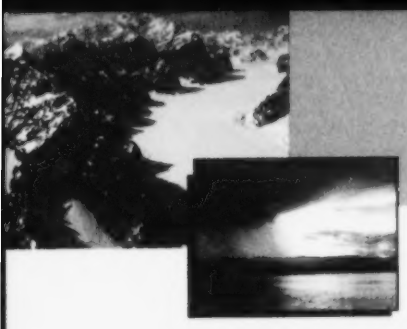
Hydroclimatic Variations in BC and Yukon Watersheds

Climate change can have significant effects on water resources in Canada, including the availability of water during the annual water cycle, and the severity of extreme events such as droughts and floods. During recent decades, hydrologic changes in natural streamflow systems in British Columbia and the Yukon have shown a strong climate signal—with streams in the interior of BC exhibiting an earlier spring freshet and extended summer recession, and streams in the Yukon having significantly higher flows

One of a spatial illustrations of ice cover change projected by the Canadian Centre for Climate Modelling and Analysis (CCCma) model. The light color indicates ice cover over the 1971-1990 normal; the dark color is for 2041-2060. The left panel is March; the right panel is September. The CCCma model projects essentially ice-free Arctic in summer by the middle of the century. Projected changes in sea-ice cover are especially worrisome, and have potentially important consequences for transportation, Arctic ecosystems and indigenous people



Average streamflows at Sullivan Creek near Canyon for periods 1975-1986 and 1987-1998 as modelled (left) and observed from large-scale climate data (right)



Collaborating on Climate Impact Studies

In the early 1990s, trembling aspen began to suffer dieback and reduced growth in some areas of Alberta and Saskatchewan due to a combination of climatic factors and defoliation by the forest tent caterpillar. Exceptionally warm temperatures across most of Canada and severe drought in parts of the western interior in recent years have raised concerns about the status of these important forests under climate change. To address the issue, the MSC's Prairie & Northern Region, the Canadian Forest Service and other partners are collaborating on a long-term research and monitoring effort involving aspen stands from the Northwest Territories to southern Manitoba. Using tree-ring analysis and other methods, they hope to determine how climate and insects affect interannual variation in the growth of these forests.

PEI Sea-Level Rise Study

The Climate Change Action Fund report *Coastal Impacts of Climate Change and Sea-Level Rise on Prince Edward Island* was published on March 1, 2002. The report details the findings of a study carried out by the MSC in cooperation with federal, provincial, municipal and institutional partners that combined the use of long-term tidal records, ice-cover trends and the regional storm-surge model. The study resulted in several scientific outputs, including the development of a storm-surge climatology for the province and various socio-economic impact and adaptation scenarios. This information is of great value to Emergency Measures staff in PEI in warning citizens of impending flooding events and providing tailored information for coastal areas. The City of Charlottetown is using the results in its planning, as well as in issuing new building permits for coastal land.

Air Quality Research

Effects of Smog on Heart and Blood Vessels

A joint study involving the MSC, Health Canada, and the universities of Michigan and Toronto, has found new evidence that smog has a direct effect on the heart and blood vessels. Scientists demonstrated that when polluted air is inhaled, it enters the lungs and starts a chemical chain reaction that causes blood vessels to constrict slightly. Although this would not likely harm a healthy person in the short term, it could have a significant impact on those with heart disease or circulatory problems, possibly even triggering a heart attack.

Northern Atmospheric Contaminants

Atmospheric mercury and ozone depletion events have been observed in the High Arctic during polar sunrise. Although the mechanisms remain enigmatic, bromine radicals have been identified as potential oxidizers—contributing significantly to the destruction of ozone in the polar stratosphere and, in their reactive form, playing a key role in mercury oxidation and boundary-layer ozone depletion. In order to identify sources and quantify the atmospheric origins of contaminants in northern regions, a second intensive measurement campaign took place in spring 2001 in Kuujjuarapik, Quebec. The effort, which involved researchers from MSC Quebec, the Institut de Recherche Scientifique (Quebec), the University of Crete (Greece), and the Institut für Umweltphysik (Germany), revealed that mercury depletion episodes are also active in the Low Arctic, are not restricted to the polar sunrise, and occur at night as well as during the day.

Air Quality Models Applications Group

The MSC has received new resources to deliver results identified in the Canada-US Ozone Annex related to the identification of the transboundary component of ozone and particulate-matter episodes. These resources will contribute to the creation of a core Air Quality Models Applications Group at the Canadian Meteorological Centre, to provide scientific support for policy and decision making. In order to maximize the use of internal expertise and synergies, all activities related to air quality prediction within CMC will be merged under this new group. An important aspect of the air quality models applications group strategy is to provide MSC regions with resources to create or further develop modelling and analysis expertise in order to take advantage of existing collaborations with other levels of government in Canada.

Hydrology: Water Science

Water Monitoring in a Dry Season

Water shortages are becoming more frequent in Canada due to significant development at the watershed level. In situations where demand exceeds the available supply, conflicts occur between competing needs for water to sustain environmental, economic, and recreational activities.

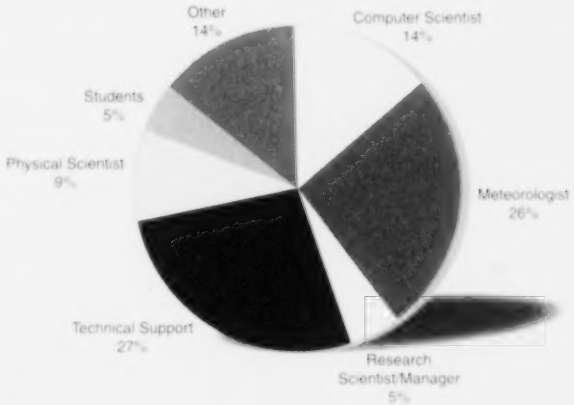
In 2001, water shortage became acute in the Prairies. The Water Survey Division (WSD) of the MSC's Prairie & Northern Region responded by providing critical data and information to the agencies responsible for water management at the watershed and interjurisdictional levels. During the spring freshet, irrigation, and energy-demand seasons, data were collected, processed and disseminated to users in the three Prairie provinces and the northern United States. To ensure compliance with established water allocations, monitoring and reporting of hydrologic conditions was greatly increased at some 250 hydrometric sites across the Prairies. This effort is expected to continue in 2002-03, due to ongoing low-flow and drought conditions in watersheds that have allocated their firm supply of water.

Federal Water Research Network

MSC's water science and policy sections participated in an EC-led interdepartmental initiative to establish a Federal Water Research Network. In August 2001, six federal departments met to identify priority areas for water research and explore opportunities for cooperation and collaboration. Since then, the MSC has worked closely with EC's National Water Research Institute and with other departments, such as Agriculture and Agri-Food Canada and Natural Resources Canada, to identify priority areas, including severe weather events, ground-to-surface-water interaction and how it relates to water quality and quantity issues, and the coupling of atmospheric, hydrologic and biological models to address water-quality source and contamination issues.

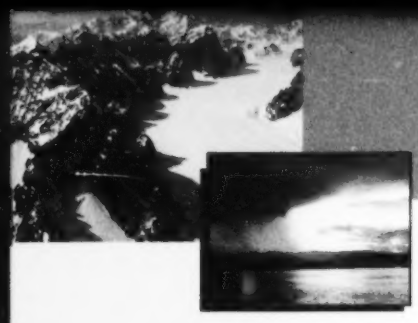
4. HUMAN RESOURCES

MSC Employee Breakdown by Classification



Meteorologist Recruitment and Training

In September 2001, candidates from across Canada began the Meteorologist Operational Training Program at MSC training centres in Dartmouth (Nova Scotia), Montreal (Quebec), and Edmonton (Alberta). In January, they travelled to the Canadian Meteorological Centre to learn about operations, speak with MSC scientists, and meet other trainees. In March, 17 new meteorologists graduated and proceeded to their first weather-centre posting.



Recruitment for the next course, which begins in September 2002, resulted in nearly 200 applicants and 24 qualified candidates being given offers. This represents the capacity of the current training program.

Technical Workforce Renewal

National Recruitment and Training Program

The Water Survey program took a significant step in addressing the aging of its technical workforce by developing a national recruitment and training program. A national competition attracted 1300 applications, from which 55 potential candidates were selected. The Saskatchewan Institute of Applied Science and Technology delivered the first 10-week course to 15 new recruits and four technicians, all of whom graduated at the end of March and are now working in the MSC's regions. The regions also took advantage of the course to provide operational health and safety training to nine existing employees. A second course for an additional 17 recruits is planned for the fall of 2002.

Atmospheric Monitoring Technologists

A new occupational training program and recruiting policy was developed for atmospheric monitoring technologists. Objectives were developed for a web-based distance-learning package, and a national recruitment plan was established. Both will be implemented in 2002-03.

National Atmospheric Monitoring Conference

A National Atmospheric Monitoring Conference targeted at the MSC's technical atmospheric workforce was held in January 2002. The objectives of the conference were to provide perspectives on monitoring program priorities and strategic plans, promote knowledge-sharing between the regional and national offices, offer opportunities for the transfer of technologies and exposure to innovative technological developments, and improve communication skills.

Other Learning Opportunities

➤ The MSC has entered into a learning partnership with the U.S. National Weather Service and the University Corporation for Atmospheric Research. COMET is the foundation for a more formalized approach to the training and development of operational meteorologists. Two MSC meteorologists have been assigned to work at COMET's state-of-the-art training facility in Boulder, Colorado, where 14 MSC students recently completed the second Winter Weather Course. Under the COMET partnership, all distance-learning training materials (Web casts, CD-ROMs, tele-training sessions) are now available to MSC offices at no charge. A web site (NORLAT) has also been developed as a one-stop shop for training materials and meteorological information related to northern latitudes.

➤ The Prairie Storm Prediction Centre in Winnipeg, Manitoba, developed and implemented Project Phoenix - a training system that simulates a weather centre, in order to help prepare forecasters for the future. The three-person simulator allows forecasters to fine tune their skills in critical time-frames, such as the first 24 hours. Nowcasting, as this type of forecasting is known, puts more emphasis on the analysis and diagnosis of weather observations, the forecasting of significant weather, and the utility of the forecast. The system is expected to become an ongoing training mechanism for forecasters.

Awards

Each year, MSC staff receive awards for their outstanding contributions to the field of meteorology. Following is a list of some of the many individuals who received recognition in 2001-02.

...Phillips receiving the ...e of Canada from Governor ...al Adrienne Clarkson

External Awards to MSC Staff

Order of Canada

On December 4, 2001, MSC senior climatologist David Phillips received the Order of Canada, our country's highest honour, for promoting awareness and understanding of our country's climate.

Awards from the Canadian Meteorological and Oceanographic Society (CMOS):

- The Dr. Andrew Thomson Prize in Applied Meteorology was awarded to Michel Jean for his work in Numerical Weather Prediction (NWP) and numerical modelling, tracking the movement of airborne material from volcanic eruptions and nuclear and other environmental emergencies.
- The Rube Hornstein medal in Operational Meteorology was presented to Phil Chadwick for his leadership in Canadian operational meteorology and for his creativity in communicating aspects of meteorology.
- A CMOS Citation was given to Eldon Oja for his work in promoting science in public education.

Internal Awards to MSC Staff

- ***Patterson Distinguished Service Medal:*** was given to Jim Abraham, Director of Meteorological Research Branch, in recognition of his many years of dedication to the science of meteorology and its application to weather forecasts and warnings in Canada.
- ***Jim Bruce Award:*** Steve Ricketts, manager of the Prairie Aviation and Arctic Weather Centre, was instrumental in combining the Arctic Weather Centre and Northern Alberta Environment Services Centre to create an aviation centre of excellence.
- ***Diversity Leadership Award:*** Srinivasan Venkatesh was recognized for his dedication to developing a workplace that supports diversity, and for his commitment and leadership in implementing EC's Employment Equity Plan.
- ***Citations of Excellence:*** Terry Allsopp, Christina Brown, Beryl Cahoon, Yves Durocher, Ted Eperson, Angus Fergusson, André Ferland, Frank Froude, Bob Hale, Dale Harvey, Victoria Hudec, Stephen Miller, Sandy Stefanofski, Andy Yun, Ted Yuzyk, Blaine Jelley, Spencer Silver, Diana Verseghi, Yvonne Cook, Krystyna Czaja, Hoppa Lau, Mike Minuk, Xiaolan Wang, Tsoi Yip, Heather Strathearn, and Michel Nadeau.

Safety and Health of Employees

Ice-Thickness Measurements

After being terminated at all sites in 2000 due to costs and occupational health-and-safety concerns, the ice-thickness program was reinstated by MSC Prairie and Northern Region in January 2002. Data on sea and lake ice thickness and on-ice snow depth are being collected at 10 sites in the high Arctic, with seven additional sites to be added in fall 2002. The program will continue to the end of the 2004-05 season, when the data will be used to create a summary report on ice-thickness trends and variability.

A significant amount of work went into developing a Task Hazard Analysis for the program, and investigating, testing and purchasing personal protective equipment. Safe work practices and training materials were developed and documented, and are available as a template for other activities.

Technical Workforce Renewal

National Recruitment and Training Program

Atmospheric Monitoring Technologists

National Atmospheric Monitoring Conference

Other Learning Opportunities

CGSB, I Class - February 2002

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David Phillips receiving the Order of Canada from Governor General Adrienne Clarkson

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Awards from the Canadian Meteorological and Oceanographic Society (CMOS):

- The J.P. Andrew Thomson Prize in Applied Meteorology was awarded to Michel Jean for his work in Numerical Weather Prediction (NWP) and mesoscale modelling. Insights he has contributed to NWP, including material fluxes, diffusion, sensitivity and ensemble and other environmental considerations.

- The Rube Hornstein medal in Operational Meteorology was presented to Phil Chadwick for his leadership in Canada's operational weather forecasting and his innovative recommendations to improve weather forecasts.

- A CMOS Citation was awarded to Glen Greenwood for his contributions to safety to public education.

Internal Awards to MSC Staff

- *Patterson Distinguished Service Medal* was given to Jim Abraham, Director of Meteorological Research Branch, in recognition of his many years of dedication to the science of meteorology and its application to weather forecasts and warnings in Canada.

- *Jim Bruce Award* was given to Ken Hodgins, Regional Director, Ontario Region, for his outstanding contributions to the development and implementation of Atmospheric Environment Service's Northern Ozone Environmental Message Service and for his strong support of Science Fairs.

- *Diversity Leadership Award* was presented to Ken Macpherson, Regional Director, Prairie and Northern Region, for his dedication to creating a workplace that supports diversity, and for his commitment and leadership in implementing the Employment Equity Plan.

- *Citations of Excellence* were given to Bruce Archibald, Bryan Cameron, Yves Demers, Jeff Dickison, Andrea Fennessey, Andre Gagnon, Frank Hounsell, Dave Hill, Hervey Mallett, Shelley Marshall, Wendy Mercer, Sandy Mitchell, Andre Methot, Jeff Ehnes, Bruce Sawyer, Sylvie Thériault, Dennis Trudgeon, Maxwell Urad, Kevin Vickers, Hugues Vincent, Mike Wasney, Steve Wortzman, Jim Yap, Heather Steenhuis, and Michael Sitwell.

Safety and Health of Employees

Ice Thickness Measurements

After being contacted by the Occupational Safety and Health Committee, Ontario Region, MSC Toronto, Northern Region and Ottawa, MSC Ottawa, the Ontario Region Committee decided to investigate the safety of ice thickness measurements. Ice thickness measurements are taken by MSC staff to provide information to the public on the safety of ice for recreational activities. Ice thickness measurements are taken at a number of locations in Ontario, Manitoba and Saskatchewan. The investigation was carried out by the Ontario Region Committee and the Ottawa Committee. Ice thickness measurements are taken by MSC staff to provide information to the public on the safety of ice for recreational activities. Ice thickness measurements are taken at a number of locations in Ontario, Manitoba and Saskatchewan. The investigation was carried out by the Ontario Region Committee and the Ottawa Committee.

5. TECHNOLOGY

Data Monitoring and Acquisition

Network Modernization

- Comprehensive testing and evaluation of new systems and sensors including gauges for measuring total precipitation and rate of rainfall has led to their acceptance for the MSC's national weather and climate networks. MSC's expert assessment of this technology has proven of great importance to our partners (such as Environment Alberta), as they use our results to modernize their own monitoring programs.

- Action Plan 2000 funding of $4.5 million over four years will significantly enhance Canada's northern climate monitoring program. Equipment to upgrade 15 observing stations and equip two new ones has been purchased and will be installed in 2002-03. These stations will become part of Canada's commitment to the Global Climate Observing System Surface Network, and will provide important automated climate data over the sparsely populated but vast northern territory. The data are eagerly anticipated not only by Canadian researchers, but also by the international community.

- In July 2001, the CCGS Sir Wilfrid Laurier became the first ship equipped with the new Automatic Voluntary Observing Ship System (AVOS) semi-automatic weather observing system. The system has since been installed on eight other ships, with six more installations planned for 2002-03 and a total of 75 scheduled for the longer term. AVOS takes hourly observations of climate quality, representing a 10- to 100-fold increase over standard synoptic observations made on VOS ships. Despite this large volume, virtually no AVOS observations have been flagged or rejected by the quality control system.

AVOS system tilt tower, weather sensors, and data acquisition unit installed on ship deck

Technology Improvements for Forecaster's Desktop

Over the last two years, a team of regional and national MSC informatics personnel undertook a major initiative to replace obsolete operational forecaster stations with contemporary PC-based commodity platforms. The process began with upgrades to the network and server infrastructure in 2000, and continued as enhancements were made to several software applications to support higher-resolution displays. The new platform is expected to reduce average ownership costs by 75 per cent due to more competitive pricing, reduced maintenance costs, and ease of replacement. A standard hardware platform will also allow future improvements in desktop software to be designed, developed and implemented more rapidly.

Service Delivery

Emerging technologies: MSC continues to explore innovative ways to deliver weather warnings and information to Canadians in time for them to take action to protect themselves and their property. Technologies, such as cell phones, palm organizers, laptop computers, the Internet and digital radios, offer a variety of future opportunities. These include the use of crawler messages that scroll across TV screens to warn viewers of severe weather, and technologies that interrupt automated radio broadcasts during weather-warning situations.

E-Delivery Systems

In 2001-02, the MSC made a variety of improvements to its delivery of services through enhanced use of electronic media, in particular the Internet. Following are some examples.

- ***Single-Window Web Site:*** In spring 2001, the MSC began amalgamating four weather Web sites from across Canada into a Single Window on the Weather. The new site, launched in July 2001, provides the public with easy access to current weather warnings, forecasts, satellite and radar imagery, weather maps and more. Available at www.weatheroffice.ec.gc.ca (English) and www.meteo.ec.gc.ca (French), the site received over 600 million hits in the first quarter of 2002.

➤ *Media Web Site:* A new restricted-access site was developed to provide improved access to weather information by the media. The official launch of the web site will take place in fall 2002.

MSC's Globe Cyber Café showcased e-government, new Internet technologies, and a variety of Environment Canada products and services at the Globe 2002 International Environmental Trade Show and Conference in Vancouver, BC.

Weatheradio

Infrastructure Rust-Out

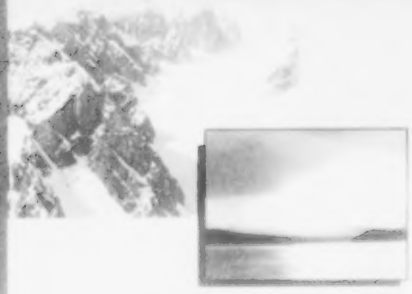
Over the past three years, the MSC committed a capital investment of over 1.5 million dollars to address significant rust-out issues associated with the Weatheradio network. These funds were utilized to replace aging voice-delivery platforms, VHF radio transmitters and associated equipment. The investment restores good health to the Weatheradio network which is a valuable MSC broadcast weather warning system for Canadians.

Official Languages Compliance

In order to comply with the requirements of the Official Languages Act, Weatheradio broadcasts across Canada are now available in both English and French. Although over 85 per cent of the network was affected, it took only eight months to implement the program-content change by May 1, 2002. A number of options were considered—including the use of dual frequencies—however, the most efficient and cost-effective choice was to cycle broadcasts in both languages on the same frequency.

National Standards for Products and Services

For many years, MSC products such as warnings, forecasts and reports were continually adapted and modified for a variety of different clients. The resulting multitude of formats not only increased training requirements for forecasters, but also made performance-measurement activities more difficult and software systems more complex. MSC's increasing reliance on automated processes for the production and delivery of products, and the need for public information to be clearly conveyed and understood, also pointed to the need for common standards in format and content. In response to this challenge, the MSC introduced a single national format for warnings in fall 2001. New format and content standards will be implemented for routine public forecasts in fall 2002.



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AWOS system sits inside shelter, sensors, and data acquisition unit installed on shop floor.

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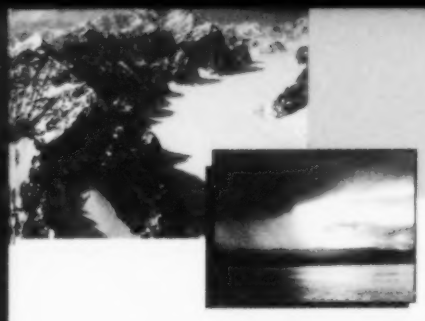


6. INTERNATIONAL ACTIVITIES

World Meteorological Organization

Canada, through the MSC, is a key player in the World Meteorological Organization. It cooperates by participating in global telecommunications networks and by respecting international data standards for the global exchange of meteorological data and products. These data are shared with more than 179 countries around the world. Thousands of volunteer severe-weather watchers, ham radio operators and shipboard observers assist in monitoring Canada's weather and climate.

Intergovernmental Panel on Climate Change

MSC coordinates Canada's contribution to the work of the Intergovernmental Panel on Climate Change (IPCC). Thirty scientists from government (including MSC), universities and the private sector worked within the IPCC to prepare the Panel's Third Assessment and related Special Reports. The MSC continues its involvement within the IPCC in the preparation of the Panel's Fourth Assessment, including being a member of the IPCC Bureau of Working Group Two, Impacts and Adaptation.

Cooperative Meteorological Programs with China

We have a number of cooperative agreements such as the collaboration of the MSC and the China Meteorological Administration (CMA). The Meteorological Service of Canada and the China Meteorological Administration first signed a Memorandum of Understanding (MOU) on Cooperative Meteorological Programmes on June 1, 1986. The MOU focused on cooperation and exchanges between technical experts to improve the coordination of national programs directed at the provision of meteorological and related services. During a Joint Working Group meeting in October the MOU was re-negotiated. After 15 years of collaboration, a new MOU on Science and Technology Related to eteorology, Hydrology, Environmental Predictions and Climate Change was signed.

Marc Denis Everell and Qin Dahe sign the MOU

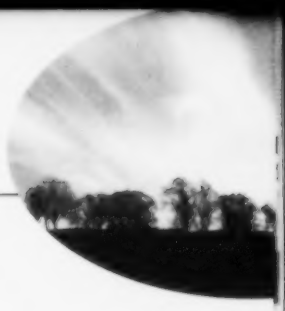
The Chinese delegation was led by Dr. Qin Dahe, Administrator of CMA and noted climate scientist seen here with Marc Denis Everell following the signing ceremony.

Canadian Weather Research Program

The Canadian Weather Research Program (CWRP), developed under the leadership of the Canadian government, is a partnership between government, universities and the private sector to promote research initiatives on weather forecasting. Strong ties with the United States Weather Research Program and the World Weather Research Program will accelerate the development of new methods and more efficient ways to forecast weather and reduce the impacts of extreme events. Two substantial initiatives led by McGill University have received $3M in funds from the Canadian Foundation for Climate and Atmospheric Science (CFCAS). These projects have substantial MSC involvement, and will advance research and development in the analyses and prediction of heavy precipitation using the MSC modelling and radar infrastructure. Other current CWRP projects include an international study on aircraft icing hazards, and the study of hurricanes affecting Atlantic Canada.

The Mackenzie GEWEX Study

A variety of hydrology, climate/meteorology and extreme weather studies are being carried out in the Mackenzie River Basin by MSC Prairie and Northern Region staff as part of Canada's contribution to the international Global Energy and Water Cycle Experiment (GEWEX) program.



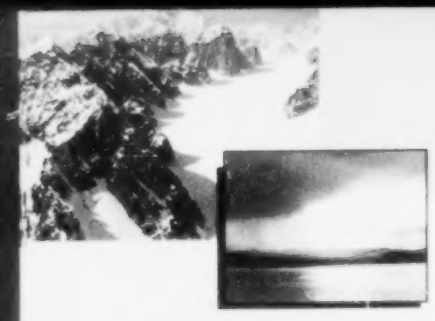
The Region also hosted a Mackenzie GEWEX workshop on Hydrologic and Climatological Scaling Issues in Yellowknife in June 2001.

Hydrologic-process field studies and modeling are being conducted in the subarctic Canadian Shield in partnership with universities and other government agencies. These processes will be incorporated into land-surface schemes and hydrological models that will allow scientists to better predict the effects of climate change and industrial development on water resources in the region. Meteorological studies are also being carried out to document and improve understanding of extreme weather characteristics and lightning in the Mackenzie Basin, and potential changes due to climate change. Relatively high lightning activity in the Basin plays a significant role in triggering forest fires, which allows new plants and trees to grow and helps control diseases and insects. Data from the Canadian Lightning Detection Network showed evidence of complex interactions between circulation patterns, storms, forest fires, and fire-enhancing smoke. Partners are being considered for investigations into the links between climate, fire, vegetation and wildlife populations.

Molecule-trapping Coating Wins R&D Award

Establishing air-quality standards requires accurate measurements of pollutants in the air – a difficult task given the variety of sizes and kinds of particulates, and the fact that many pollutants exist in both particle and gas phases. A new fine XAD sorbent coating developed by the Lawrence Berkeley National Laboratory in collaboration with the MSC and the U.S. EPA has greatly improved the accuracy of such efforts, and won the Research and Development 100 Award.

The coating has 1 000 times the available surface-area-to-volume ratio of conventional, highly porous sorbent polymers. Applied to the inside surfaces of annular diffusion denuders (gas strippers), it traps molecules of organic gases, while allowing particles to travel straight through to a filter. This technology has revolutionized monitoring strategies for characterizing ambient particulate matter, and is used in studies of semi-volatile organic compounds at Environment Canada, throughout the United States and in Europe. Among these are investigations of the atmospheric behaviour of diesel, other vehicle exhausts, and wood smoke; their role in smog formation; and the characteristics of pollutant particles.



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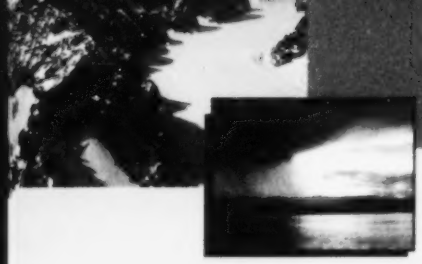
Molecule-trapping Coating Wins R&D Award

Establishing air-quality standards requires accurate measurements of pollutants in the air – a difficult task given the variety of sizes and kinds of particulates, and the fact that many pollutants exist in both particle and gas phases. A new fine XAD sorbent coating developed by the Lawrence Berkeley National Laboratory in collaboration with the MSC and the U.S. EPA has greatly improved the accuracy of such efforts, and won the Research and Development 100 Award.

The coating has 1,000 times the available surface area-to-volume ratio of conventional, highly porous sorbent polymers. Applied to the inside surfaces of annular diffusion denuders (gas stoppers), it traps molecules of organic gases, while allowing particles to travel straight through to a filter. This technology has revolutionized monitoring strategies for characterizing ambient particulate matter, and is used in studies of semi-volatile organic compounds at Environment Canada, throughout the United States and in Europe. Among these are investigations of the atmospheric behaviour of diesel, other vehicle exhausts, and wood smoke; their role in smog formation; and the characteristics of pollutant particles.



IV. Where We Are Going

MSC in Transition

Renewal is an important component in the lifecycle of any organization that has existed for a long time. In the 130 years since the MSC was created, rapid advances in science and technology and the ravages of time have caused parts of the MSC's monitoring infrastructure to rust out or become obsolete. In addition, the Service is faced with the reality of an aging scientific workforce.

A broad-based and permanent solution is needed to manage the threat posed by these infrastructure and human-resource issues, to restore the integrity of Canada's weather and water service, and to move towards its vision. As such, the MSC will address these issues over the next three years by:

- increasing spending on recruitment and training to create a continuous flow of scientists and technicians into meteorological, hydrological and related scientific fields;
- moving to a philosophy of "life-cycle management" for critical infrastructure, so that all new equipment installed is maintained at a specific standard, and its eventual replacement is planned;
- improving the quality and effectiveness of its high-impact weather and hazardous events program by focusing on relevant research and development (e.g. moving to higher resolution and regional mesoscale models), automated guidance for forecasters, and increasing community services.

By setting priorities and targets to rejuvenate its staff, reshape its efforts, retool its infrastructure and reposition itself in the marketplace, the MSC will continue to meet the changing needs of Canadians both in and beyond this century.

A Vision for the Future

The MSC is moving towards two long-term results—protecting Canadians against imminent or short-term weather and environmental hazards, and helping them adapt to their environment on all time scales. The MSC's vision is to be:

- an essential national institution that contributes to the health and safety of Canadians and their communities through innovative science, service and technology;
- a catalyst and scientific partner in developing innovative services in support of economic efficiency, productivity and competitiveness;
- accountable to Canadians for quality and program effectiveness through charters of service, annual reports and practices of modern management;
- a recognized authority and source of science and information in the areas of weather, climate, water and related environmental issues;
- a recognized contributor to Canada's international role in helping to solve complex and multidisciplinary environmental issues facing global society in the coming decade; and,
- a valued, strategic and innovative partner with other government agencies, academia and industry in achieving shared goals.

OPERATIONAL MEASURES

Warning Verification

Measuring the accuracy and timeliness of warnings and forecasts is an important yet difficult task for the MSC. Performance measurement activities serve three main purposes: first, they help identify where research is needed to improve the techniques and technologies behind the modern forecast system; second, they help forecasters identify individual training needs; and third, they give the general public, media and decision makers an analysis of the quality of service provided.

Warnings and forecasts represent separate challenges in terms of performance measurement. While it is possible for the MSC to determine the extent and impact of larger-scale storms, Canada's relatively sparse observation network does not always capture smaller-scale high-impact weather events. As such, the MSC must often rely on reports provided by citizens through the public media. These reports present a challenge not only in terms of data capture and electronic storage, but also because they frequently lack the details needed to determine the precise extent and impact of such events.

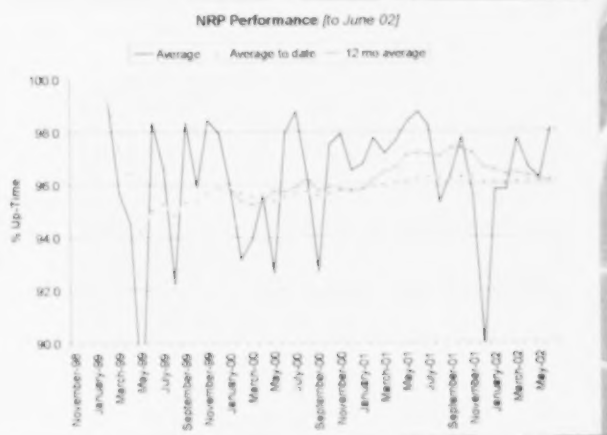
The MSC has launched a two-year development program for measuring the accuracy and timeliness of its warnings, with an initial focus on smaller-scale severe summer thunderstorm and tornado events. Software has been developed to receive and analyze data in 2002-03 and to capture and store all warnings issued by the MSC. The development of high-impact-winter-weather and large-scale-storms-event data capture will be completed in the coming year.

Forecast Verification

A new initiative for measuring the accuracy of routine public forecasts is underway, with a pilot system expected to be delivered by the end of the 2002-03 fiscal year and a fully operational system implemented in all public forecast centers in 2003-04. With these two performance measurement initiatives completed, the MSC will be able to deliver a comprehensive accounting of its public forecast and warning responsibility.

Performance of Radars

For the past year the National Radar Project's radars have been, on average, operational more than 96% of the time with the highest one month average being over 98%.



Canadian Meteorological Centre (CMC) Production System

Quality Improvements in CMC Products

After months of preparation, the implementation of a new analysis and modelling system in December 2001 resulted in an internationally acclaimed improvement of the MSC's forecast guidance products. These improvements stemmed from research and development efforts carried out by both the Meteorological Research Branch and the CMC over the last few years. They include the following:

- Major improvements were incorporated into the CMC's operational data assimilation system. This system provides a realistic representation of what is happening in the atmosphere and is an essential

V. Selected Performance Information

OPERATIONAL MEASURES

Warning Verification

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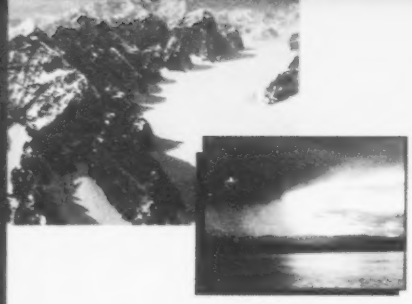
CLIENT SATISFACTION MEASURES

Post-Event Surveys on Weather Warnings

Graph showing percentage of time forecasts are within 3 C of the actual observed temperature at 23 selected stations across Canada. The observed improvement over the years corresponds to improvements to the numerical weather prediction and post-processing systems.



component in providing weather forecasts. These improvements resulted in better data availability and significant improvements in forecasts in the Southern Hemisphere and on the west coast of North America.

- Significant changes were implemented to the Canadian Numerical Weather Prediction model. These included the addition of a scheme to the global forecast model that vastly improves the realism of mountain effects on atmospheric circulation, and the reduction of some numerical filtering. These improvements are showing benefits to the full suite of operational products, including emergency response products.
- The CMC incorporated a new module into its regional forecast model that takes into account more terrestrial vegetation and surface types, including land, water, sea ice and glaciers. The exchange of heat and humidity between the subsoil, the earth's surface and the lower atmosphere is also more realistic.

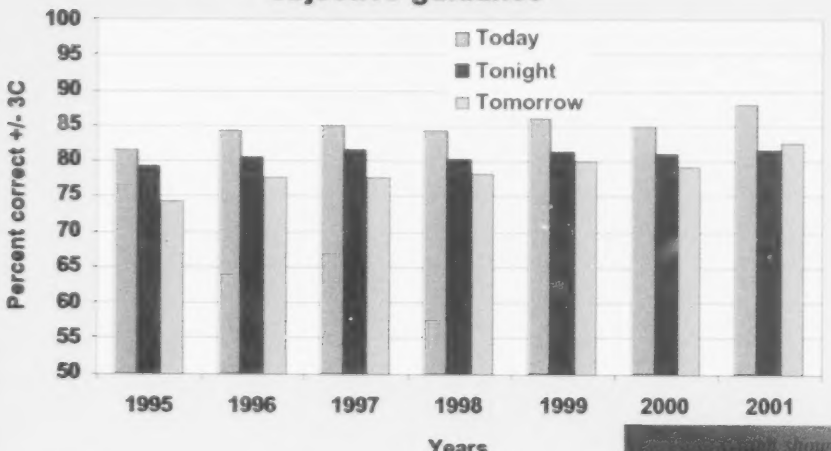
Such improvements form the basis on which MSC will continue to build upon to improve the accuracy of its forecasts, including precipitation. Every Canadian is touched by these changes either directly or indirectly as the services provided to us by weather forecasters from coast to coast have significantly improved. More information is available on the CMC web site: http://www.smc-msc.ec.gc.ca/cmc/index_e.html

CLIENT SATISFACTION MEASURES

The MSC regularly consults its clients, including the general public, through surveys and focus groups. The results are used to ensure that products and services meet public and client needs and expectations and to determine if changes or improvements are required.

Post-Event Surveys on Weather Warnings

The MSC commissioned several surveys following severe weather events (tornadoes and winter storms) to determine how many Canadians actually hear or see warnings of impending severe weather, the actions taken, and the impact of the events. These surveys help to improve understanding of public perceptions and behaviour with respect to severe weather and warning messages, and to measure the effectiveness of such warnings in reducing negative impacts.

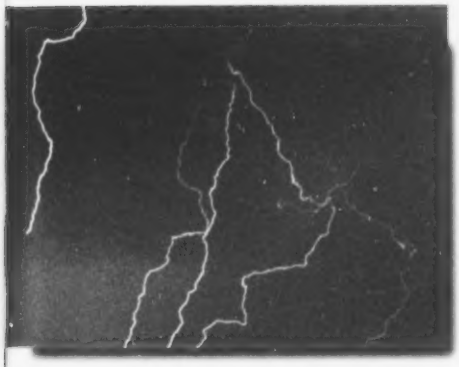


Graph showing percentage of time forecasts are within 3 °C of the actual observed temperature at 23 selected stations across Canada. The observed improvement over the years corresponds to improvements to the numerical weather prediction and post-processing systems.

Post-event surveys were conducted in the following locations:

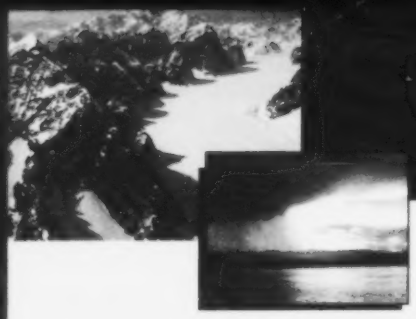
Summer 2001:	Alma/St. Gedéon (tornado) Chicoutimi (tornado)
Winter 2001-02:	Winnipeg (heavy snowfall) Greater Toronto Area (heavy snowfall/freezing rain)

Results confirm that the vast majority of Canadians receive weather warnings via the mass media, especially television. While most respondents feel that warning messages are very important and provide them with sufficient information to take protective action, for most events the number of respondents who had heard or seen a warning was low, and the number that took action even lower. The survey results are being used to sharpen the MSC's public outreach and education programs.



Other Feedback Methods

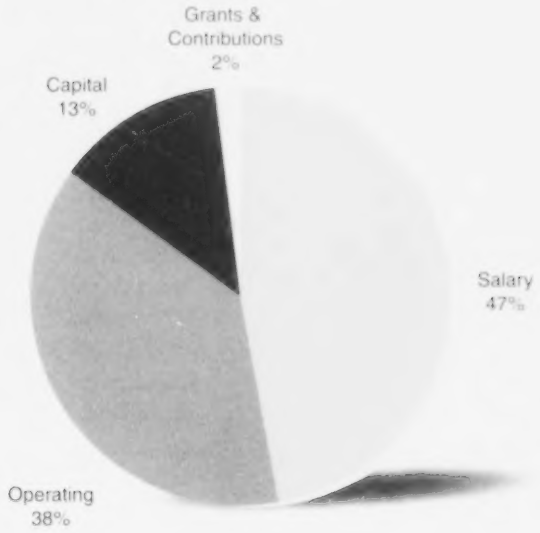
The MSC successfully responded to over 40 000 inquiries received via its web site and national 1-800 enquiry line (1-877-789-7733). Approximately 99% of the inquiries were received via the web site. The majority of the inquiries pertained to areas such as public forecasts, weather warnings and severe weather and archive data.



VI. Selected Financial Information

MSC Total Expenditures 2001/02

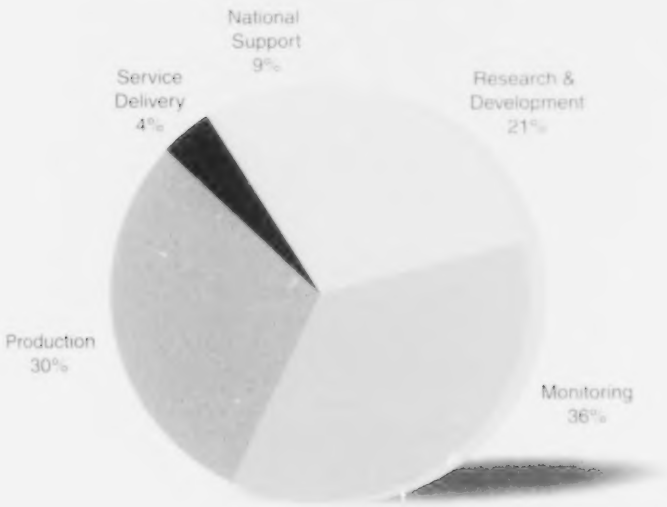
MSC Total Expenditures by Input Factor 2001/02



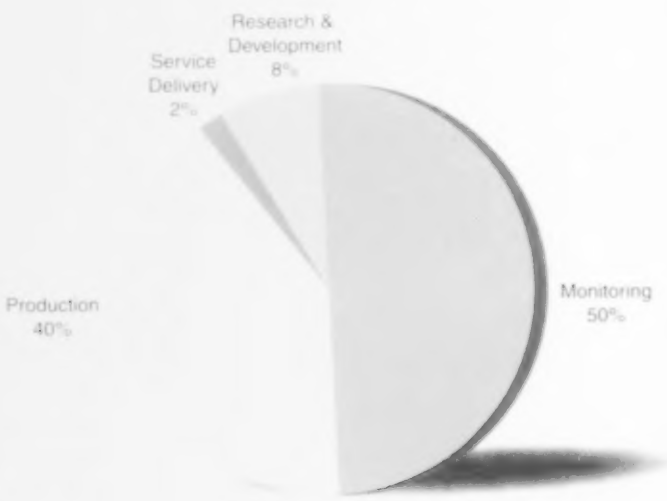
MSC Total Expenditures for 2001/2002

	Salary	Operating	Capital	Grants & Contributions	Total
MSC Atlantic	8,467,811	4,751,611	1,130,956	-	14,350,378
MSC Quebec	10,259,179	6,706,054	1,784,295	200,000	18,949,528
MSC Ontario	11,538,629	7,744,329	1,505,159	-	20,788,117
MSC P&N	21,842,370	18,204,319	4,636,056	35,000	44,717,745
MSC P&Y	11,345,438	8,166,470	2,878,382	9,132	22,399,422
MSC HQ	57,071,222	52,109,377	20,370,301	5,203,590	134,754,490
Total	**$120,524,649**	**$ 97,682,160**	**$ 32,305,149**	**$ 5,447,722**	**$255,959,680**

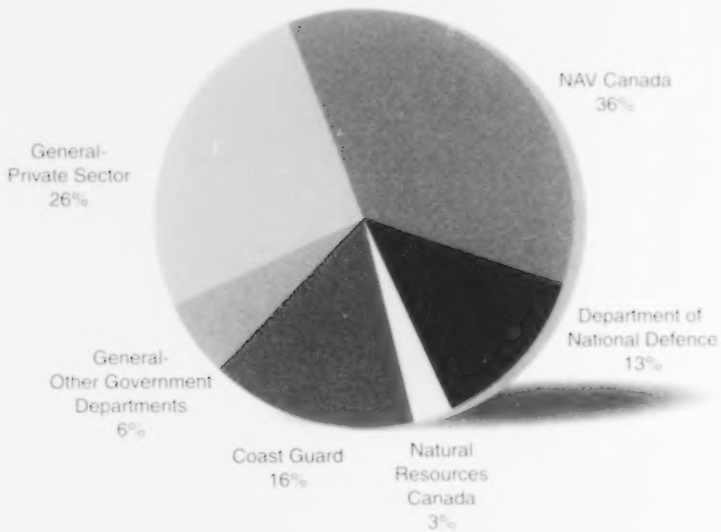
MSC Total Expenditures by Function



MSC Revenues by Function



MSC Revenues by Client



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Freezing rain – D. Huang, Newfoundland Weather Centre
Storm surge – Canadian Hurricane Centre (CHC)
ii David Anderson – David Anderson
iii MSC ADM
1 MSC Downsview Building – O. Koursa
2 Staff discussing air quality information – MSC, Atlantic Region
2 Canadian Ice Service Aircraft – Services Clients & PartnersDirectorate (SCPD)
2 Supercomputer – Canadian Meteorological Centre (CMC)
2 AVOS Computer System – Atmospheric Monitoring and WaterSurvey Directorate (AMWSD)
3 Hurricane Gert – CHC
3 Water dam – H. Aucoin
3 Advisory Board – ADM-MSC Office
4 Scientist taking rain gauge measurement – MSC-OR Informatics
4 Executive secretary – D. McDonald, MSC, Downsview
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7 Running tests on a volunteer – SCPD
8 Military Plane – Department of National Defence
8 NAV CANADA Flight Services Specialist – NAV CANADA
9 Iceberg – Newfoundland Weather Centre
11 Lab technician – D. McDonald, MSC, Downsview
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19 MSC's Globe CyberCafe showcase – Pacific and Yukon Region
20 Marc Denis Everell and Qin Dabe (CMA Administrator) – B. Angle, MSC, Gatineau
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